

**REMARKS****I. Drawings**

The Examiner indicated that there needs to be changes to explain the following:

The Examiner asserted that claim 12 claims an integrator but there exists no diagram where this is to be placed among the physical and neural network schematics.

The Examiner also argued that claim 19 claims a summation (circuit) but there exists no diagram where this is to be placed among the physical neural network schematics.

The Examiner further asserted that claim 21 claims there exists a location where comparison occurs but there exists no diagram where this is to be placed among the physical neural network schematics.

The Applicant notes that claim 12 has been amended such that claim 12 no longer refers to the integrator.

Regarding claim 19 and a "summation (circuit)" the Applicant notes that claim 19 does not refer to a "summation (circuit)", but instead refers to the step of determining said excitation level of at least one neuron of said plurality of neurons based on a weighted sum of input signals received over respective nanoconnections among said plurality of nanoconnections, said nanoconnections being associated with respective weights; and adjusting each of said weights when said at least one neuron of said plurality of neurons and a corresponding one of said others of said neurons fire within a prescribed time interval. The Applicant submits that there is not a summation (circuit) claimed in claim 19. Additionally, the Applicant notes that the activity of "summation" is shown in Applicant's drawings. For example, see block 2606 of Applicant's FIG. 26.

The Applicant further notes that claim 21 has been cancelled by amendment. The Applicant thus submits that the Examiner's objections to the drawings are rendered moot in light of these amendments and remarks.

## II. Claim Rejections 35 U.S.C. § 112

Claims 1-3, 6, 7, 9-21, 23, 24 were rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failure to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Examiner asserted that the entire set of claims use at least one of the three terms 'nanoparticles', and 'nanoconductors'. The Examiner also argued that in some claims these are equivalent and can be interchanged with one another and in other claims one seems dependent upon another which contradicts the interchangeability of the three terms. The Examiner indicated to review all the claims and make changes to reflect the invention and avoid ambiguous meanings or interpretations.

The Applicant respectfully disagrees with this assessment. Claims 1-3, 6, 7, 9-21, 23 and 24 do in fact particularly point out and distinctly claim the subject matter which the Applicant regards as the invention. The terms "nanoconnections" and "nanoconductors" are not utilized interchangeably as the Examiner argued, but instead are properly used in the claims to indicate that the nanoconductors are used to form the nanoconnections. For example, in claim 1, the Applicant indicates that the at least one synapse is provided by a plurality of nanoconnections formed from a plurality of nanoconductors disposed and free to move about within a dielectric liquid solution in association with at least one pre-synaptic electrode and at least one post-synaptic electrode thereof and an electric field applied thereof, wherein said dielectric liquid solution comprises a mixture of a dielectric solvent and said plurality of nanoconductors. There is not a problem with this language with respect to 35 U.S.C. 112, because it is clear that the nanoconnections are formed from the

nanoconductors (i.e., the plurality of nanoconnections are formed from the plurality of nanoconductors). That is, the nanoconnections comprise nanoconductors.

Thus, when the claims refer to a nanoconnection, the claims refer to just that...a nanoconnection. When the claims refer to a nanoconductor, the claims refer to just that...a nanoconductors. A nanoconnection is actually a component, a connection, that utilizes nanoconductors. When the claims refer to a plurality of nanoconnections, the claims are referring to a multiplicity of nanoconnections. When the claims refer to a plurality of nanoconductors, the claims refer to a multiplicity of nanoconductors. The Applicant has taken great care to refer to the proper terminology in the claims and such, there is clearly no ambiguity in the claims. The use of such terminology may be complex, but is clearly not ambiguous. Additionally, the Applicant notes that the word "nanoparticle" is not even used in the claims as argued by the Examiner.

The Applicant requests that the Examiner identify where the term "nanoparticle" is used in the claim language. The Applicant's specification, of course, does teach that a nanoparticle is a type of nanoconductor. The Applicant has amended the claims slightly as indicted herein in an attempt to clarify some of the use of phrases such as "strengthening at least one nanoconnection among said plurality of nanoconnections" to simply "strengthening said plurality of nanoconnections". However, the Applicant believes that there still remains no ambiguity in the claims with respect to "plurality of nanoconnections," "plurality of nanoconductors," "nanoconductors," "nanoconnections" and so forth. The Applicant invites the Examiner to reread the claims again with this in mind, paying special attention to the fact that the nanoconnections are actually formed from the nanoconductors and that the words nanoconnections and nanoconductors are not utilized interchangeably.

The Examiner also rejected claims 1, 2, 6, 9, 13, 23 under 35 U.S.C. 112, second paragraph as being indefinite for failing to particularly point out and

distinctly claim the subject matter which applicant regards as the invention. The Examiner asserted that these claims contain the terms 'dielectric solution, and/or 'dielectric solvent'. The Examiner argued that in claim 23 the 'dielectric solution' at the beginning of the claim turns into 'dielectric solvent' at the end of the claim. Please review all the claims and make changes to reflect the invention and avoid ambiguous meanings or interpretations.

The Applicant respectfully disagrees with this assessment. Claims 1, 2, 6, 9, 13 and 23 are not indefinite and do not fail to particularly point out and distinctly claim the subject matter which the Applicant regards as the invention. In fact, the opposite true. For example, the terms dielectric solution and dielectric solvent are used properly throughout the claims. For example, the Applicant refers first to the liquid dielectric solution and then indicates that the liquid dielectric solution comprises a mixture of a dielectric solvent and said plurality of nanoconductors. This is what a solution is. A solution includes a solvent. In Applicant's case, the solution is made from a mixture of a dielectric solvent and the plurality of nanconductors.

Thus, Applicant does properly and particularly point out and distinctly claim the subject matter which the Applicant regards as the invention. This is also true, for example, in claim 23, where the Applicant states at the beginning of claim 23 that a dielectric liquid solution comprises a mixture of a dielectric solvent and a plurality of nanoconductors. Again, the Applicant does properly and particularly point out and distinctly claim the subject matter which the Applicant regards as the invention. There is no ambiguity here. If necessary, the Applicant requests that the Examiner telephone the Applicant so that the Applicant can go through each claim element to demonstrate that the claims are not indefinite and do in fact particularly point out and distinctly claim the subject matter which the Applicant regards as the invention.

Based on the foregoing, the Applicant respectfully requests withdrawal of the rejection to claims 1, 2, 3, 6, 7, 9-21 and 23-23 under 35 U.S.C. 112, second paragraph.

### III. Claim Rejections 35 U.S.C. § 103

#### ***Requirements for Prima Facie Obviousness***

The obligation of the examiner to go forward and produce reasoning and evidence in support of obviousness is clearly defined at M.P.E.P. §2142:

The examiner bears the initial burden of factually supporting any *prima facie* conclusion of obviousness. If the examiner does not produce a *prima facie* case, the applicant is under no obligation to submit evidence of nonobviousness.

M.P.E.P. §2143 sets out the three basic criteria that a patent examiner must satisfy to establish a *prima facie* case of obviousness:

1. some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings;
2. a reasonable expectation of success; and
3. the teaching or suggestion of all the claim limitations by the prior art reference (or references when combined).

It follows that in the absence of such a *prima facie* showing of obviousness by the Examiner (assuming there are no objections or other grounds for rejection), an applicant is entitled to grant of a patent. *In re Oetiker*, 977 F.2d 1443, 1445, 24 USPQ2d 1443 (Fed. Cir. 1992). Thus, in order to support an obviousness rejection, the Examiner is obliged to produce evidence compelling a conclusion that each of the three aforementioned basic criteria has been met.

**McHardy**

The McHardy reference has been utilized by the Examiner as a basis for rejecting Applicant's claims. The Applicant believes it would be helpful, prior to engaging in a refutation of the Examiner's rejections, to analyze McHardy and distinguish McHardy from Applicant's invention, and to outline the differences between McHardy and Applicant's invention before proceeding to engage in a claim by claim discussion of the Examiner's rejections.

The device of McHardy and Applicant's invention are both used in the context of microelectronic networks. This is, however, where the similarity ends. The following discussion is intended to illustrate, in the most direct and simplest way possible, the significant differences between McHardy and Applicant's invention.

The following discussion is intended as a systematic deconstruction of the McHardy device and Applicant's invention and is meant as a way to illustrate the many and significant differences between these two devices. The Applicant will begin with a short description of each device.

**The McHardy Synapse**

The McHardy synapse is a chemical device whose foundation is the process of electroplating. The McHardy synapse requires four basic circuit elements to function:

1. DC voltage source
2. Migratable metal
3. Non-Migratable metal
4. Permanent interconnect.

These components can be seen in Figure 1 below:

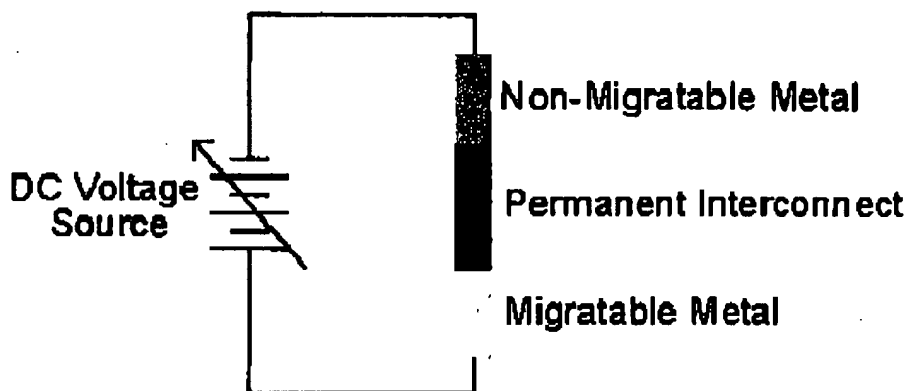


Figure 1

For the McHardy synapse to function, the materials that compose the device must display very particular properties with the Applicant will now explain.

**Figure 1**

**Migratable metal**—according to McHardy, many forms of metals can be considered “migratable” including silver, copper, bismuth, cadmium, tin, and lead. In the context of the McHardy synapse, a metal is considered migratable if an ion can be produced in the presence of a moisture film and a voltage source so that the metal ion can move or *migrate* through the moisture film.

**Non-Migratable metal**—As one might suspect, a non-migratable metal is a metal that does not dissolve in the presence of a moisture film and applied voltage. According to McHardy, non-migratable metals include gold, indium, palladium and platinum.

**Permanent Interconnect**—According to the McHardy patent, the permanent Interconnect can take one of two forms. First, the permanent interconnect may be composed of carbon with an absorbed moisture film on the surface of the carbon interconnect (e.g., see claim 6 of McHardy). Second, it may

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be composed of mixed halides of rubidium with copper or silver (e.g., see claim 7 of McHardy).

The purpose of the permanent interconnect is to facilitate the conduction of **ions** through or across the material. As the ions precipitate to atoms **on or in** the material, they form conducting filaments that bridge the pre- and post-synaptic (anode and cathode) terminals. This process is directly related to electroplating and was inspired by a device invented by Bernard Widrow in the 1960's that used electroplating to build an electrochemical synapse known as the "memistor".

The process of metal migration and deposition used in the McHardy synapse is illustrated in Figure 2

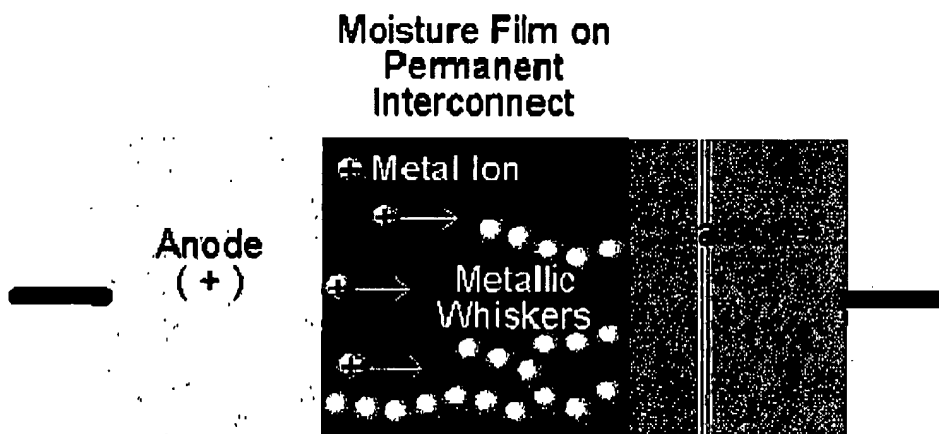


Figure 2

As detailed by McHardy (i.e., see C1, L45-55 of McHardy), metal migration takes place between conductors in an active electronic circuit in the presence of a moisture film. Under the influence of a DC voltage, metal ions dissolve from the positive conductor (the anode). The ions migrate through the moisture film (the electrolyte) and plate out on the negative conductor (the cathode). The deposit

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often takes the form of metallic whiskers which eventually reach the anode and create an ohmic contact.

### Applicant's Invention

Applicant's invention essentially utilizes 4 basic circuit elements to function:

1. Voltage source (AC or DC)
2. Pre-synaptic and post-synaptic electrodes (any conductive substance)
3. Non-electrically conductive viscous solution (liquid dielectric)
4. Electrically conductive (preferably charge-neutral) nanoparticles

An illustrative example of Applicant's invention is shown in Figure 3 below.

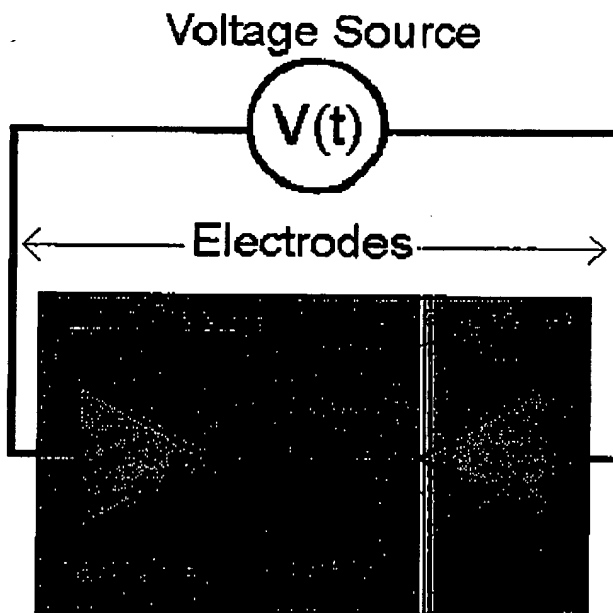


Figure 3

The operation of Applicant's invention is as follows. Pre-synaptic and post-synaptic electrodes (shown as gold/yellow in Figure 3 above) are charged with a voltage source. This voltage may be DC or AC, though AC is preferred. The applied voltage generates an electric field between the electrodes. The region between the electrodes is comprised of a liquid dielectric and nanoparticles. The inhomogeneous electric field generates a dipole in the nanoparticles. The dipole induced force, which results from the interaction of the applied electric field with the dipole, draws the nanoparticles into the region between the electrodes. The accumulation of nanoparticles between the electrodes facilitates the electrical conduction between the electrodes.

The physical process of moving particles with a dipole-induced force in association with a dielectric medium is also known as dielectrophoresis, which will be discussed in greater detail shortly.

### **Device Physics**

In order to further explain the context of Applicant's invention, the Applicant now explains two principles at work, dielectrophoresis and Brownian motion.

### **Dielectrophoresis**

The use of nanoparticles (e.g., nanoconductors) in a dielectric solution and exposed to electric fields as taught by Applicant's invention is described by the scientific principals of dielectrophoresis (also referred to as "DEP"). The concept of dielectrophoresis was presented in the following article, which was submitted with Applicant's original Information Disclosure Statement (IDS).

Hermanson et al., "Dielectrophoretic Assembly of Electrically Functional Microwires from Nanoparticle Suspensions," Materials Science, Vol. 294, No. 5544, Issue of 2 Nov 2001, pp. 1082-1086

The Examiner is invited to review the IDS documents that have been submitted as part of the prosecution of this patent application for the Hermanson et al article. The concept of dielectrophoresis is additionally discussed in the following paper, which was also included with Applicant's original IDS:

Smith et al., "Electric-field assisted assembly and alignment of metallic nanowires," Applied Physics Letters, Vol. 77, No. 9, 28 August 2000, pp. 1399-1401

In order to understand Applicant's invention, however, a short discussion of the concept of dielectrophoresis would be helpful.

When a particle is suspended in a dielectric liquid medium and subjected to an electric field, the electric field induces a polarization in the particle. If the field is homogeneous, the induced dipole aligns in the direction of the field. If the field is inhomogeneous, the particle will feel a force. The direction of the force is determined by the dielectric properties of the particle and suspension. If the particle is more polarizable than the surrounding medium, the particle will feel a force in the direction of increasing field gradient, which is termed **positive DEP** (pDEP). On the other hand, **negative DEP** (nDEP) results when the medium is more polarizable than the particle. At low frequencies, charge accumulation at the particle/medium boundary contributes to the induced dipole, which is referred to as the **Maxwell-Wagner Interfacial Polarization** and is a function of the particle and medium conductivities. As the frequency is increased, this term of the polarization has increasingly less of an effect, as mobile charges do not have time to move an appreciable distance. For the case of a spherical particle, the time-averaged DEP force is given by:

$$\bar{F}_{dep} = 2\pi r^3 \epsilon_0 \epsilon_m \operatorname{Re} \left[ \frac{\epsilon_p^* - \epsilon_m^*}{\epsilon_p^* + 2\epsilon_m^*} \right] \nabla E^2$$

Equation 1

For any geometry other than a sphere or ellipsoid, an analytical derivation of the DEP force is not trivial, and the applicability of Equation 1 requires the particle radius to be small compared to the changes in the gradient of the energy density ( $\nabla E^2$ ). This is certainly not the case for Applicant's synapse geometries, as the nanoparticle will be of equal magnitude to the inter-electrode spacing. For the case of coplanar electrodes, finite element simulation has found that the maximum DEP force occurs when the particle radius is on the same order as the electrode width. A general conclusion is that the force calculated from Equation 1 will give an underestimate of about 20%, as the equation does not include higher-order moments that become increasingly important for large bead sizes.

It is evident from Equation 1 that the DEP force is dependant on real part of the **Clausius-Mossotti (CM) Factor**

$$\frac{\epsilon_p^* - \epsilon_m^*}{\epsilon_p^* + 2\epsilon_m^*}$$

Equation 2

The value of the CM factor determines the sign of the force. For positive values, the force is directed along the direction of maximum field gradient. For a Known™ connection, we require positive DEP to attract nanoparticles to an electrode gap and **Brownian Motion** to remove the nanoparticle. The CM factor is determined by the particle and mediums complex permittivity, which can be expressed as,

$$\epsilon^* = \epsilon - \frac{\sigma}{\omega} i$$

Equation 3

where  $\sigma$  is the conductivity of the material. Equation 3 warrants special attention. The relative permittivity and conductivity of the bead and the medium determines a cross over frequency, where the DEP force transitions from positive DEP to negative DEP. This can be seen in Figure 6 below for latex beads in methanol.

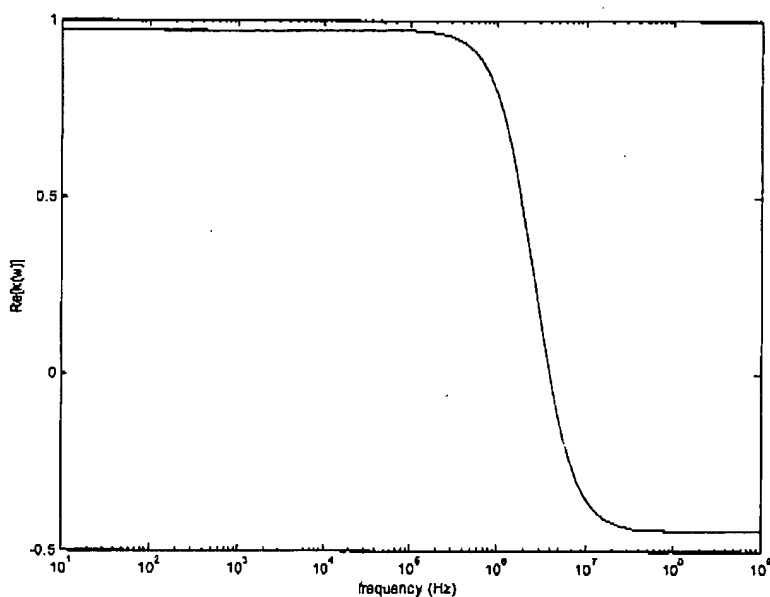


Figure 6

Real Part of the Clausius-Mossotti Factor, the frequency-dependant term in Equation 1, showing the cross-over between positive and negative DEP

The transition from positive DEP to negative DEP is dependant on the conductivity of the bead and medium. The real part of the CM factor is given by:

$$\text{Re}[CM] = \left[ \frac{(\epsilon_p - \epsilon_m)(\epsilon_p + 2\epsilon_m) - \frac{1}{\omega^2}(\sigma_m - \sigma_p)(\sigma_m + \sigma_p)}{(\epsilon_p + 2\epsilon_m)^2 + \frac{1}{\omega^2}(\sigma_m + \sigma_p)^2} \right]$$

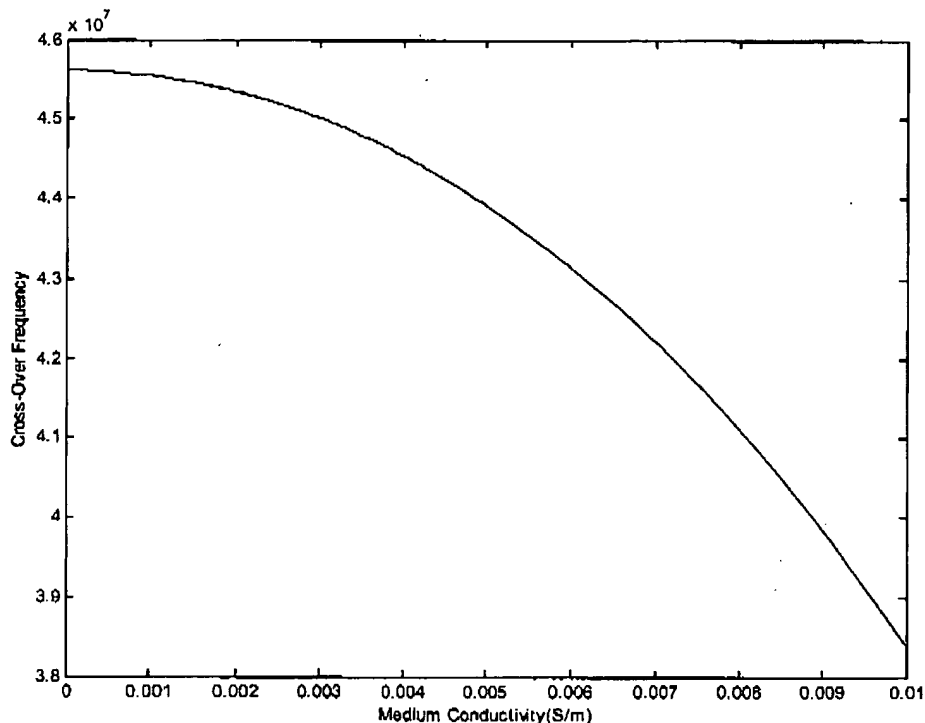
Equation 4

One can see that as the frequency is increased, the conductivity becomes increasingly insignificant. The crossover frequency can be found from Equation 4 and is given by:

$$\omega = \sqrt{\frac{(\sigma_m - \sigma_p)(\sigma_m + \sigma_p)}{(\epsilon_p - \epsilon_m)(\epsilon_p + 2\epsilon_m)}}$$

Equation 5

Figure 7 shows the cross over frequency plotted against the medium conductivity.



**Figure 7**

Cross Over Frequency vs. Medium Conductivity for Latex Beads

One can see from Figure 8 that the cross over frequency remains between 3.8 and 2.6 MHz for conductivities below the conductivity of latex. For example, a frequency greater than 5 MHz will always result in negative DEP for this particle/solution combination. More important for applications of Applicant's invention, however, is the strength of positive DEP for low frequencies. Figure 8 plots the maximum CM factor for low-frequency positive DEP versus medium conductance.

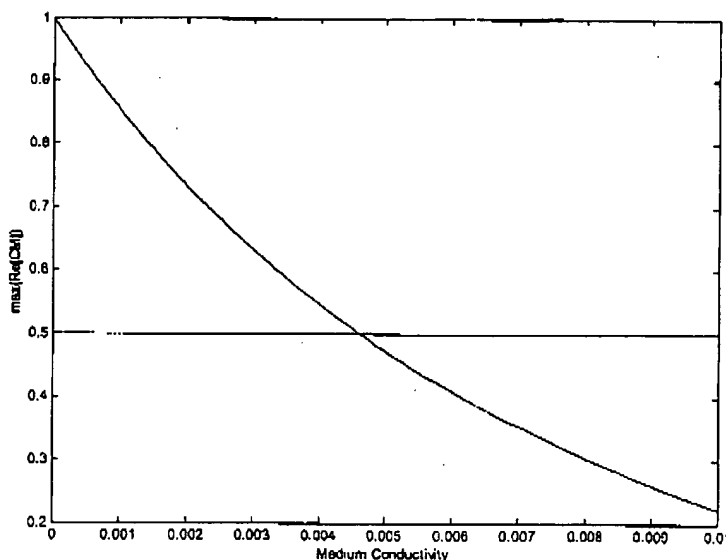


Figure 8

Low-Frequency (+DEP) CM Factor versus Medium Conductivity(S/m)

The key point is that DEP is a well-developed field. There are at least 3 textbooks that deal exclusively with the topic and hundreds of published papers. As in almost all physical models, there is the first-order theory, which is outlined in almost every DEP paper, and then there are the second order effects. Some of these effects included variations in polarizability from non-spherical particles and low-frequency charge accumulation and a resulting field cancellation, among others. Most individuals claiming DEP is an "unreliable" or "hard to control" force has usually tried to apply first-order theory to complex particle-medium solutions like living cells. In the case of Applicant's invention, we are in the pDEP saturated region, far from any dispersion frequency. A Known particle/medium solution is highly controlled and characterized. As long as pDEP increases the probability that

a particle will be attracted to an electrode gap, and Brownian motion acts to remove a particle from an electrode gap, the requirements of Applicant's are met. Indeed, these are not difficult requirements to meet.

When Applicant's patent was originally filed, there was some uncertainty as to the likelihood of DEP forces overcoming Brownian motion at the nanoscale. Because of this, the Applicant discussed the use of carbon nanotubes, which can be highly polarizable due to their elongated structure. Over the last several years it has become clear, however, that the DEP force will reliably attract spherical nanoparticles and even individual proteins, as one learned from section 1.1. Fortunately, Applicant essentially took care to include *any* nanoconductor in the claims.

First order theory is counter-intuitive when it comes to scaling. From the ubiquitous equation first derived by Pohl, one can see that the force is proportional to the particle volume:

$$\bar{F}_{dep} = 2\pi r^3 \epsilon_0 \epsilon_m \operatorname{Re}[K(\omega)] \nabla E^2 \rightarrow \left(\frac{4}{3}\pi r^3\right) \frac{3 \cdot 2}{4} \epsilon_0 \epsilon_m \operatorname{Re}[K(\omega)] \nabla E \rightarrow \frac{3}{2} V \epsilon_0 \epsilon_m \operatorname{Re}[K(\omega)] \nabla E$$

In a more traditional mode of thinking it would be desirable to move a particle perfectly deterministically from one location to another. Yet as the particle becomes smaller, the DEP force decreases while Brownian motion becomes more dominant. This would seem to spell a recipe for disaster. However, Applicant's invention is designed to work within this stochastic regime. This is very important to understand. Applicant's system does not "cope" with random thermal bombardment: it requires it. A complete understanding as to how Applicant's system thrives in this chaotic environment is beyond the scope of this document, but suffice it to say, a connection cannot be changed unless the connection can be

broken. We leave the breaking to Brownian motion and the repair to the electric fields generated in electrode gaps by sub-surface circuitry.

### **Brownian Motion**

English botanist Robert Brown first noticed the random motions of tiny particles in a liquid media in 1827. Brown was quite astonished when pollen grains that had been stored for a century moved around in a zig-zag pattern under the magnification of his microscope. Naturally, he thought them to be alive. In 1877 Desaulx formulated the correct hypothesis when he stated that, "In my way of thinking the phenomenon is a result of thermal motion in the liquid environment (of the particle)". In 1889 G.L. Gouy made the observation that this movement, termed "Brownian motion", was more apparent for smaller particles and higher liquid temperatures. Thus the quantitative study of the movement of microscopic particles under the influence of random thermal motion was born.

Einstein received a Nobel Prize in part for his mathematical description of Brownian motion, which he produced in 1905 along with his more famous theories. Interestingly, Einstein was not aware of the experimental validation already existing of his work. He was focused on finding a way to prove beyond a reasonable doubt the existence of atoms. The derivation of the mean squared displacement can be found in various forms, but Applicant recommends the interested reader to refer to the following link: <http://www.mathworld.com>.

The average radial displacement depends on the particle radius,  $a$ , solution viscosity,  $\eta$ , solution temperature,  $T$ , and of course the time interval,  $t$ .

$$\langle r^2 \rangle = \frac{kTt}{\pi\eta a}$$

The Applicant's connection is therefore formed from a series of nanoparticles bridging a common electrode gap, where each particle or chains of particles form a conducting bridge or channel from pre- to post-synaptic electrodes. To model the system in the simplest and most efficient way possible, we can determine the probability that a particle will be attracted to an electrode gap in a time interval given the temperature, viscosity, particle size and of course the pDEP force acting on the particle. This probability will also be a function of the gap geometry and particle-electrode affinities. Despite the complexity of the particle-electrode interaction, it is a relatively simple matter to measure these probabilities experimentally.

#### **Device Differences**

As stated before, both the device of McHardy and Applicant's invention are intended as a micro-fabricated artificial synapses and that is where the similarity ends. The McHardy device and Applicant's invention, however, operate on completely different physical processes. This fundamental difference is obvious to many. However, the subject matter is difficult and new, so it has become clear that what may be obvious to some may not be obvious others. This section is intended to compare some of the ways the devices are different so as to aid the patent examiner in understanding the underlying physics of the two devices.

#### **Summary of Significant Differences**

1. Use of permanent interconnect versus non-use
2. Electrochemical versus electromechanical
3. DC voltage versus AC voltage
4. Metal ions versus conductive nanoparticles
5. Use of Migratable metals versus non-use

The average radial displacement depends on the particle radius,  $a$ , solution viscosity,  $\eta$ , solution temperature,  $T$ , and of course the time interval,  $t$ .

**1. Use of permanent interconnect (McHardy) versus non use (Applicant's invention).**

As stated previously and illustrated in Figure 1 and the McHardy Patent, **the McHardy synapse requires a permanent interconnect** between the anode and cathode to facilitate the migration of metal ions from the migratable metal to deposition on the interconnect. The use of this permanent interconnect is fundamental to the operation of the McHardy synapse is explicitly explained throughout the McHardy patent and in all claims.

**Applicant's invention requires no permanent interconnect.** Instead, a dipole-induced force, positive dielectrophoresis, attracts nanoparticles (not limited metal ions) to regions of high energy density, concentrating in the particles in regions where the electric field is highly divergent. Although this process might seem confusing to those not familiar with the principles of dielectrophoresis, the interested reader can find numerous textbooks, scientific papers and websites dedicated to the process of dielectrophoresis. One particularly informative article on the topic of DEP and nanotechnology is available for free on the Internet at:

<http://www.foresight.org/Conference/MNT7/Papers/Hughes/index.html>

**2. Electrochemical versus Electromechanical**

The McHardy synapse utilizes chemical a process to achieve connection variation. The chemical process is fundamental to its operation and described in detail throughout the patent and stated as a limiting aspect of the invention on every single claim. The balancing electrochemical reactions are shown clearly (C5 L40-65) and make use of the pH changes at the anode and cathode by the electrolyses of water.

By stark contrast, the Applicant's invention is *electromechanical*. No chemical bonds are broken nor made during device operation. The dipole-induced force acts to accumulate particles between electrodes to facilitate electrical

conduction. Although Applicant's connection could be built with water, the electrolyses that make the McHardy synapse viable could degrade Applicant's synapse by creating hydrogen and oxygen gas. In all likelihood, water will not be used in a Applicant's synapse. Substances like ethanol, methanol, and toluene are more likely candidates.

### **3. DC voltage versus AC voltage**

The McHardy synapse requires a DC voltage for operation. The electrochemical process can only function in a condition of known DC bias. Indeed, electro migration cannot be defined without reference to a DC bias. Chemical reactions occur on the *anode* and *cathode*. Reversal of the DC bias changes the operational characteristic of the device.

Applicant's synapse, again in stark contracts to the McHardy synapse, is not dependant on voltage polarization. A dipole-induced force is independent of voltage polarization. Applicant's synapse utilizes a voltage bias across a connection to attract nanoparticles to an electrode gap and random thermal motion to disperse the nanoparticles. See earlier discussion regarding these two competing forces.

### **4. Metal ions versus conductive nanoparticles**

The McHardy synapse requires the formation of metal ions. In this respect, it is absolutely critical that one of the electrodes be of a type that will permit this process, what McHardy refers to a "Migratable Metal". The metal atom must attain charge by losing electrons on a moisture film. The charged atom then feels an electrostatic force, which pulls it toward the cathode where it regains its electrons and is deposited on a permanent interconnect. The function of this devise is not defined without the present of charged metal atoms or ions.

In stark contrast to the McHardy synapse, Applicant's synapse does not require metal ions. The principles that makes Applicant's synapse operational,

(e.g., dielectrophoresis) does work on charged particles. However, it is advantageous that a particle be charge-neutral so that the only appreciable force felt by the particle is the dielectrophoretic force which will tend to accumulate the particles only between the electrodes rather than all over the anode or cathode. All of this goes without saying that a conductive nanoparticle, as described by the Applicant's invention, is not the same as a metal ion. Rather, a metal ion is a subset of the "nanoparticle" class, which could include larger molecules such as DNA or carbon nanotubes, accumulations of elementary material like gold nanoparticles or nanowires, substances like latex nanospheres or complex particles consisting of combinations of many types of molecules or atoms.

#### **5. Use of Migratable metals versus non-use**

The McHardy synapse requires that a synapse be constructed from two types of metals forming the pre- and post-synaptic electrode terminals. One metal must be a "migratable" metal and the other must be a "non-migratable" metal. McHardy defines a migratable metal as a metal that will form ions in the presence of an electrolyte and an applied voltage. The McHardy synapse is not defined outside of the scope of a device constructed entirely from non-migratable metal. McHardy lists gold as one type of non-migratable metal.

In stark contrast, Applicant's synapse does not require a distinction between migratable and non-migratable metals. Applicant's invention can be constructed entirely on non-migratable metals because its operation is not dependant on metal ions and the effects of electroplating.

It is clear from the foregoing, that the "neuron" of Applicant's Invention is not equivalent to the "metallic whisker" of McHardy. It is also clear that Applicant's "synapse" is not equivalent to the "synapse" of McHardy. Given the differences outlined above, the Applicant believes that McHardy clearly does not anticipate, suggest and/or teach Applicant's claims.

**McHardy, Nagahara, Kaler**

Claims 1-3, 9, 10, 23 and 24 were rejected by the Examiner under 35 U.S.C. 103(a) as being unpatentable over McHardy in view of Nagahara and further in view of Kaler (U.S. Patent No. 5,315,162 referred to as **McHardy**; 'Directed placement of suspended carbon nanotubes', referred to as **Nagahara**; U.S. Patent Publication 20030048619, referred to as **Kaler**).

**Claim 1**

Regarding claim 1, the Examiner argued that McHardy teaches providing an artificial physical neural network (**McHardy**, abstract) comprising at least one neuron and at least one synapse thereof. (**McHardy**, abstract; 'Neuron' of applicant is equivalent to 'metallic whisker' of McHardy. 'Synapse' of applicant is equivalent to 'synapse' of McHardy.)

The Examiner admitted that McHardy does not teach wherein said at least one synapse is provided by a plurality of nanoconnections formed from a plurality of nanoconductors disposed and free to move about within a dielectric liquid solution in association with at least one pre-synaptic electrode and at least one post-synaptic electrode thereof and an electric field applied thereof, wherein said dielectric solution comprises a mixture of a dielectric solvent and said plurality of nanoconductors.

The Examiner argued, however, that Nagahara teaches wherein said at least one synapse is provided by a plurality of nanoconnections formed from a plurality of nanoconductors (**Nagahara**, abstract; 'Nanoconductors' of applicant is equivalent to 'nanotubes' of Nagahara.) disposed and free to move about with a dielectric liquid solution in association with at least one pre-synaptic electrode and at least one post-synaptic electrode (**Nagahara**, abstract, p3827, C2:9-22; 'One pre-synaptic electrode' and 'one post-synaptic electrode' of applicant is equivalent to

'electrodes' of Nagahara. 'Dielectric solution' of applicant is equivalent to 'dielectric constant of the solution medium' of Nagahara.) thereof and an electric field applied thereof, wherein said dielectric solution comprises a mixture of a dielectric solvent and said plurality of nanoconductors. (**Nagahara**, abstract; 'Electric field applied' of applicant is equivalent to 'ac bias is applied' of Nagahara.)

The Examiner argued that it would have been obvious to a person having ordinary skill in the art at the time of applicant's invention to modify the teachings of McHardy by using nanoparticles for connection between electrodes as taught by Nagahara to have at least one synapse is provided by a plurality of nanoconnections formed from a plurality of nanoconductors disposed and free to move about within a dielectric liquid solution in association with at least one pre-synaptic electrode and at least one post-synaptic electrode thereof and an electric field applied thereof, wherein said dielectric solution comprises a mixture of a dielectric solvent and said plurality of nanoconductors.

The Examiner added: for the purpose of generating connections between electrodes as needed.

The Examiner admitted that McHardy and Nagahara do not teach said dielectric liquid solution within a connection gap formed between said at least one pre-synaptic electrode and said at least one post-synaptic electrode, wherein each nanoconnection among said plurality of nanoconnections is strengthened or weakened according to an application of said electric field, such that the greater an electrical frequency or an amplitude of said electric field, the more nanoconductors among said plurality of nanoconductors align to form said plurality of nanoconnections and the stronger said artificial physical neural network becomes, and wherein nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said artificial

physical neural network are strengthened; and transmitting at least one pulse generated from said at least one neuron to said at least one post-synaptic electrode of said at least one neuron and said at least one pre-synaptic electrode of said at least one neuron of said physical neural network, thereby strengthening at least one nanoconnection of said plurality of nanoconnections disposed within said dielectric liquid solution and strengthening said at least one synapse thereof.

The Examiner asserted that Kaler teaches locating said dielectric liquid solution within a connection gap formed between said at least one pre-synaptic electrode and said at least one post-synaptic electrode, wherein each nanoconnection among said plurality of nanoconnections is strengthened or weakened according to an application of said electric field, such that the greater an electrical frequency or an amplitude of said electric field, the more nanoconductors among said plurality of nanoconductors align to form said plurality of nanoconnections and the stronger said artificial physical neural network becomes, and wherein nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said artificial physical neural network are strengthened (citing **Kaler**, abstract, and arguing that nanoconnections are strengthened or weakened according to an application of said electric field' of applicant is equivalent to 'conductance and their thickness, conductivity, and also asserting that a fractal dimension can be controlled by varying the frequency and voltage of the applied field' of Kaler); and transmitting at least one pulse generated from said at least one neuron to said at least one post-synaptic electrode of said at least one neuron and said at least one pre-synaptic electrode of said at least one neuron of said physical neural network, thereby strengthening at least one nanoconnection of said plurality of nanoconnections disposed within said dielectric liquid solution and strengthening said at least one

synapse thereof. (citing **Kaler**, abstract; and arguing that 'Transmitting at least one pulse' of applicant is equivalent to 'alternating current' of Kaler. The Examiner argued that if the 'pulse' is greater than previous pulses the nanoconnection will be strengthen.)

The Examiner asserted that it would have been obvious to a person having ordinary skill in the art at the time of applicant's invention to modify the combined teachings of McHardy and Nagahara by being able to increase or decrease the conductivity as taught by Kaler to locating said dielectric liquid solution within a connection gap formed between said at least one pre-synaptic electrode and said at least one post-synaptic electrode, wherein each nanoconnection among said plurality of nanoconnections is strengthened or weakened according to an application of said electric field, such that the greater an electrical frequency or an amplitude of said electric field, the more nanoconductors among said plurality of nanoconductors align to form said plurality of nanoconnections and the stronger said artificial physical neural network becomes, and wherein nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said artificial physical neural network are strengthened; and transmitting at least one pulse generated from said at least one neuron to said at least one post-synaptic electrode of said at least one neuron and said at least one pre-synaptic electrode of said at least one neuron of said physical neural network, thereby strengthening at least one nanoconnection of said plurality of nanoconnections disposed within said dielectric liquid solution and strengthening said at least one synapse thereof.

The Examiner asserted: for the purpose employing electrical fields to generate connections and conductivity between electrodes and using these selectable and adjustable properties to construct a neural network.

The Applicant respectfully disagrees with this assessment. The Examiner noted that McHardy does not teach the use of a dielectric liquid solution. Thus, McHardy fails to teach a dielectric medium and a plurality of molecular conductors disposed in such a dielectric medium. The device of McHardy is limited to the use of migratable metals. For example, see McHardy at Col. 4, line 7, wherein McHardy refers to "migratable metals such as copper, bismuth, silver etc." The Applicant's invention may use nanoconductors such as carbon nanotubes, gold nanowires, gold nanoparticles, latex spheres, DNA, etc. In the Applicant's invention, an electric field affects such nanoparticles by inducing a dipole force. See, for example, the second paragraph on page 24 of Applicant's specification where Applicant states that "...dipole should preferably be induced in the material when in the presence of an electric field." That is, the dipole is induced in the nanoparticle/nanoconductor, which in turn causes a force towards regions of high field gradient such as the connection gap described and claimed by Applicant. Note that the direction of a dipole induced force is not necessarily the direction of the applied electric field. The electrical conduction between electrodes that form the electrode gap is regulated by the presence of nanoparticles (i.e., nanoconductors) at or near the connection gap. This process is thus electromechanical.

The use of ions by McHardy, on the other hand, is an electrochemical process. McHardy teaches "...parallel electrode reactions involving the water present in the electrolytic solution provided by the absorbed moisture" (see Col. 4, lines 21 of McHardy). It is important to understand that McHardy requires the use of chemical reactions at the electrodes. See, for example, the chemical reactions indicated at Col. 5, lines 41-42 and Col. 5, line 45 and also Col. 5, line 60 of McHardy. These are chemical reactions requiring water. Note that the Applicant's invention can use but does not require water as a dielectric solution. To summarize, Applicant's invention is electromechanical and McHardy is electrochemical. Further, McHardy requires a chemical reaction that uses water

that has been absorbed in an ion insertion compound (see Col. 5, lines 33-65 of McHardy).

The Applicant's invention is thus an electromechanical device that utilizes nanoconductors (e.g., nanotubes, nanowires, nanoparticles, DNA, etc). Each nanoconductor is an assembly of multiple atoms that can possess but may not a net charge. McHardy, on the other hand, is clearly limited to the use of metallic ions in an electrochemical process. McHardy relies upon the use of a migratable metal (again, see Col. 4, lines 1-3). A migratable metal as taught by McHardy is a metal that is ionized and is dissolved the electrolytic medium of McHardy. One feature that is particularly important to McHardy is that the solubility of the metal ions of McHardy is dependent on the pH of the electrolytic medium of McHardy (see Col. 4, line 38 of McHardy and Col. 4, line 55-65 of McHardy). The pH is in turn controlled by chemical reactions taking place at the electrodes. (See, for example, McHardy Col. 4, line 37 to Col. 6, line 11, where such chemical reactions and processes are described).

Applicant's, on the other hand, does not require the use of migratable metals as defined by McHardy's electrochemical processes. In fact, McHardy states clearly that gold is a non-migratable metal (i.e., see Col. 3, line 68), whereas with Applicant's invention, gold nanoparticles, for example, can be used in a dielectric solution to form a synapse. The following article, which was cited in Applicant's original IDS as indicated previously, discusses gold nanoparticles/nanoconductors (i.e., gold micro wires) forming connections between electrode terminals via dielectrophoresis:

Hermanson et al., "Dielectrophoretic Assembly of Electrically Functional Microwires from Nanoparticle Suspensions," Materials Science, Vol. 294, No. 5544, Issue of 2 Nov 2001, pp. 1082-1086

Gold nanoparticles are also discussed in the following reference, which as indicated previously herein, was also included as a part of the original IDS submission:

Smith et al., "Electric-field assisted assembly and alignment of metallic nanowires," Applied Physics Letters, Vol. 77, No. 9, 28 August 2000, pp. 1399-1401

Given that the foregoing, it is apparent that McHardy's metal ions cannot be classified as the Applicant's nanoparticles/nanoconductors.

As further direct evidence that the device, as described by McHardy, bears no similarity to Applicant's invention, one only need look at the title of the McHardy reference: "**Electrochemical** synapses for artificial neural networks". McHardy is based on electrochemical processes. Applicant's invention, on the other hand, as indicated previously is **electromechanical in nature**. That is, electrochemical processes do not occur with respect to Applicant's neural network device, which instead is based on electromechanical functions (e.g., conductors, dielectric, electrodes, etc).

The device, as described by McHardy, on the other hand, teaches the following **electrochemical** processes (see McHardy, C1, L46-55 and C3, L8-10):

"Metal migration is an electrochemical process related to electroplating. Metal migration takes place between conductors in an active electronic circuit in the presence of a moisture film. Under the influence of a DC voltage, metal ions dissolve from the positive conductor (the anode). The dissolved ions migrate through the moisture film (the electrolyte) and plate out on the negative conductor (the cathode). The deposit often takes the form of metallic whiskers which eventually reach the anode and create an ohmic contact."

And

"As another feature of the present invention, permanent interconnects are provided which include mixed halides of rubidium with copper or silver."

Applicant's invention does **not** utilize the metal migration process of McHardy, which requires, 1) a DC voltage, 2) metal ions, 3) a permanent connection between pre- and post-synaptic electrode that forms the cathode and 4) a reversed-biased voltage that induces chemical reactions that affect the pH of the electrolytic solution and in turn weakens the connection.

Applicant's invention 1) does NOT require (but can use) a DC voltage, but will also work with AC; 2) does NOT require metal ions, but rather can use charge neutral particles such as nanoconductors (e.g., nanotubes, nanowires, nanoparticles, DNA, etc); 3) does NOT require permanent connection between pre- and post-synaptic electrodes, but builds this connection from the nanoparticles; and 4) does not weaken connections via an electronically induced chemical process, but rather the purely electromechanical process of random thermal motion also known as Brownian motion as described by Einstein.

Thus, there are in fact significant differences in the physics between Applicant's invention and McHardy's device, in addition to incredible differences in the manner in which the devices are controlled. For example, McHardy does not teach controlling a neural network using the liquid dielectric solution of Applicant's invention.

Additionally, McHardy relies upon the use of a single permanent interconnect 16 (see FIG. 1 of McHardy) that forms an electrolytic path for ions, NOT charge neutral particles, between the input terminal 12 and the output terminal 14 of McHardy (see column 3, lines 50-52 of McHardy). An electrolytic medium is not a dielectric medium: one exists for the movement of ions to promote electrical conduction (electrolytic); the other is used specifically for its properties of canceling electric fields and inhibiting electrical conduction (dielectric). An electrolytic medium involves the use of an electrolyte and not a dielectric. McHardy provides no teaching, suggestion or disclosure of the use of such a dielectric medium.

Conductors referred to by McHardy do not constitute a dielectric solvent. Additionally, the moisture film of McHardy is not a dielectric medium. McHardy is based on the electrolytic path (interconnect 16) and hence an electrolyte, not a dielectric.

An electrolyte is a substance containing free ions which behaves as an electrically conductive medium. A dielectric, on the other hand, is basically an electrical insulator, and constitutes a substance that is highly resistant to electric current. Unlike an electrolyte, a dielectric tends to concentrate an applied electric field within itself. As the dielectric interacts with the applied electric field, charges are redistributed within the atoms or molecules of the dielectric. This redistribution alters the shape of the applied electric field both inside and in the region near the dielectric material. It is this process, when taken with the affects of nanoparticles also displaying a dielectric behavior, which causes a dipole-induced force to attract the particles to the connection gap. This is in fact the entire basis of the scientific principal of dielectrophoresis and is the electromechanical process described by Applicant's invention.

A dielectric medium is not an electrolytic medium. In fact, the use of an electrolyte teaches away from a dielectric and such materials that concentrate an applied electric field within itself. The electrolytic path of the permanent interconnect 16 of McHardy is simply not a dielectric medium as taught by Applicant's invention. The electrolytic path of McHardy extends from the anode to the cathode. In Applicant's invention, there is no such "path" because the nanoparticles are pulled into the electrode gap from the surrounding dielectric solution and not from the anode.

The Examiner asserted that the "metallic whiskers" of McHardy are equivalent to Applicant's neurons. This is the not the case. The metallic whiskers of McHardy constitute McHardy's electrochemical synapse. A neuron, however, by definition is as an active component, which means that it must amplify a signal. The metallic

whiskers of McHardy provide no mechanism for amplification and are purely intended as an electrochemical synapse. The Applicant's electromechanical synapse also does not amplify a signal and therefore cannot constitute a neuron. The Applicant's synapse and McHardy's synapse are thus as discussed previously are based on entirely different physical principals. To be clear here, the metallic whiskers or "whiskers" of McHardy are formed via an electrochemical process for the purpose of emulating a synaptic device. There is no aspect of McHardy that deals with neuronal elements and again to be clear, a synapse is not a neuronal element. Thus, the metallic whiskers of McHardy are not equivalent to any neuron let alone Applicant's neuron. The Applicant does not deny that McHardy represents an attempt at constructing a synapse. The Applicant is arguing, however, that the McHardy synapse is not equivalent to Applicant's synapse and further that the metallic whiskers of McHardy do not function or constitute neuron.

The Nagahara reference relates to the directed placement of suspended carbon nanotubes for nanometer-scale assembly. The Nagahara reference does not describe a synapse, post-synaptic or pre-synaptic electrodes or any other type of neural network components, such as neurons. A neural network and neural network components such as neurons and synapses are sophisticated devices requiring a very particular type of teaching. Applicant's specification [see Paragraph 03] does teach the following:

"Neural networks are computational systems that permit computers to essentially function in a manner analogous to that of the human brain. Neural networks do not utilize the traditional digital model of manipulating 0's and 1's. Instead, neural networks create connections between processing elements, which are equivalent to neurons of a human brain. Neural networks are thus based on various electronic circuits that are modeled on human nerve cells (i.e., neurons). Generally, a neural network is an information-processing network, which can be inspired by the manner in which a human brain performs a particular task or function of interest. Computational or artificial neural networks are thus inspired by biological neural systems. The elementary building blocks of biological neural systems are the neuron, the modifiable connections between the neurons, and the topology of the network."

Thus, in order for Nagahara to be utilized as a basis for rejecting Applicant's claimed invention under 35 U.S.C 103, Nagahara must provide for a teaching of neural networks as taught by Applicant's invention, that is, computational systems that essentially function in a manner analogous to that of the human brain or at the very least, a biological neural system including neurons, synapses, post-synaptic and pre-synaptic electrodes and so forth. Contrary to the Examiner's assertion that Nagahara teaches "at least one synapse" and "post-synaptic electrodes" and so forth, a review of Nagahara clearly indicates no teaching whatsoever of the presence in Nagahara of any teaching of any computational devices that are analogous to biological neural systems and biological neural network components such as neurons and synapses.

The Applicant further notes that the McHardy synapse is based in no part on the dielectrophoretic assembly of nanoparticles under an ac-bias. One important point to consider is that the McHardy synapse could not possibly function under an ac-bias because the technique of McHardy represents an electrochemical process based on electroplating where there must be a clear anode and cathode (i.e., NOT an alternating electric bias). The point here is that McHardy could not possibly be combined with Nagahara because the McHardy reference teachings principals and components that are completely different from that of Nagahara. The Examiner is essentially arguing that Nagahara and McHardy can be combined to produce all of Applicant's claim limitations. In order for this to be true, a dielectric solution must be equivalent to an electrolytic solution (which as explained previously, is not the case) and the electrodes of Nagahara must be composed of both migratable and non-migratable metals. In fact, Nagahara's electrodes are composed only of gold which is a non-migratable metal. McHardy points out at col. 3, line 68 that "it is required that one of the terminals be a non-migratable metal such as gold, etc..." and that the other terminal be a migratable metal such as copper, bismuth, etc. Since Nagahara's electrodes are formed only of gold they could not possibly be used

as the basis for McHardy's synapse. Furthermore, McHardy requires a permanent interconnect (e.g., see McHardy, Col. 4, line 3). There exists no permanent interconnect in Nagahara. So, how can Nagahara possibly be combined with McHardy as argued by the Examiner?

It is also significant to note that Nagahara provides absolutely no teaching of a synapse and/or of neural networks. Nagahara simply teaches a fabrication technique but there is no hint or suggestion by Nagahara that this fabrication technique could be used as the basis for an adaptive synaptic element. The only place where Nagahara even hints at the possibility that this fabrication technique could be utilized as a basis for creating some sort of device is that last sentence of Nagahara which states that "...this technique is also applicable to other molecular scale components..., and may eventually be used for making other novel functional devices". This statement is vague and ambiguous in that it is a general statement without any specific teaching of the kind of device that could be made by the Nagahara technique. In other words, creating a network of adaptive and artificial synapses is a far from obvious. Even the idea of integrating the physics of particles in a liquid as part of the device rather than a fabrication method is also far from obvious.

The Kaler reference teaches the dielectrophoretic assembly of electrically functional microwires. As in Nagahara, Kaler provides no teaching or hint that this process or device could be used as the basis for an adaptive synaptic element and in fact teaches away from that use. It is clear from Kaler that the assembly technique outlined by Kaler is intended for use as wires, sensors, switches, and logical and memory elements. For example, col. 1, paragraph 006 of Kaler indicates this. A synapse, on the other hand, is not a wire or a sensor or a switch or a logical or memory element. For example, a synapse is much more than simply a memory element. It is clear that Kaler does not intend for his dielectrophoretic technique/assembly to be used as the basis of an adaptive synaptic element.

Rather, Kaler can be used as a non-volatile memory device. See, for example, paragraph 0038 of Kaler. One suggested use of Kaler is as a non-volatile binary memory element. For example, paragraph 0038 indicates the following: "...By forming wires between the electrodes 14, their states may be flipped from very high resistivity through the water phase to very low specific resistance (typically 50  $\Omega$ ) through the wire 18, as shown in FIG. 6(b) (memorizing a 1101 sequence)...these wires 18 remain in place even after the field is turned off but can be erased by applying a burst of current of higher voltage and frequency...the system can then be rewired in a different conformation, as shown in FIGS. 6(c) and 6(d) (memorizing a 1111 sequence).."

It is thus very obvious from this language that Kaler intends his connections to be non-volatile while in a liquid and not exposed to electric fields. Kaler states clearly that his connection remains formed after the electric field is removed. This is not the desired behavior of Applicant's invention, which requires that the connection dissolve into the solution when the electric field is removed. See for example Applicant's claim 1 as follows: "...wherein nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said artificial physical neural network are strengthened".

Thus, Applicant's connections could not function according to Kaler's teachings. That is, in the absence of an electric field, Applicant's connections must weaken. This forms the basis of the ADAPTIVE nature of Applicant's invention, which distinguishes Applicant's invention from a binary switch such as that taught by Kaler. It is certainly not obvious that particles floating around on a surface of a chip subject to continual thermal bombardment from the solution could be used as a basis for a stable adaptive learning system such as that disclosed by Applicant's invention. The reason that Kaler desires his connection to be non-volatile is

because the current microelectronic industry desires high density non-volatile and inexpensive memory devices. The Applicant's invention requires volatility and the integration of liquid on the chip. This goes against current microelectronic dogma and also the Kaler reference, which is attempting to fill this need for non-volatility. The Applicant has thus turned an obvious problem of Kaler into a solution, which is entirely not obvious in light of current practices and the Kaler, McHardy and Nagahara references individually or combined with one another. Additionally, the Applicant notes that the Kaler assembly technique as utilized as a non-volatile memory element is incredibly slow and could not remotely compete with current and proposed microelectronic and nanoelectronic devices.

Again, Kaler teaches a non-volatile binary memory and not a synapse and certainly provides no hint, teaching or suggestion of neural networks and further teaches away from devices such as synapses and neural networks due to its binary nature non-volatility. Synapses and neural networks are intended to adapt and are certainly not binary. The use of a binary memory element clearly indicates that Kaler has not intention of using the Kaler technique for the purpose of producing artificial neural networks. Kaler flies in the face of even the basic components and teachings of neural networks. Thus, Kaler could not even remotely be combined with McHardy and Nagahara as asserted by the Examiner.

It is also significant to note again that McHardy is an electrochemical device and not electromechanical as stated previously. Kaler and Nagahara are illustrations of dielectrophoretic assembly processes and are thus electromechanical. Kaler and Nagahara could thus not possibly be combined with electrochemical process such as that of McHardy. By their nature, Kaler and Nagahara teach away from any combination with McHardy.

Based on the foregoing, the Applicant submits that the rejection to claim 1 fails under all there prongs of the aforementioned prima facie obviousness test. First, there is no suggestion or motivation either in the McHardy, Nagahara and

Kaler references themselves or in the knowledge generally available to one of ordinary skill in the art, to combine the teachings of McHardy, Nagahara and Kaler to provide for each and every claim limitation of Applicant's claim 1. There is also clearly not a reasonable expectation of success for such a combination given the significant differences between the devices. Third, the prior art references when combined do not provide for the teaching or suggestion of ALL the claim limitations of Applicant's claim 1.

With regard to the first prong of the prima facie obviousness test, the Applicant reminds the Examiner that the language of the references may not taken out of context without a motivation for such a combination, in effect producing the words of the claims (and sometimes, not even the words or concepts of the claims), without their meaning or context. The resultant combination of references would not yield the invention as claimed. Claim 1 is rejected under 35 U.S.C. §103(a) and no showing has been made to provide the motivation as to why one of skill in the art would be motivated to make such a combination, and further fails to provide the teachings necessary to fill the gaps in order to yield the invention as claimed, particularly given the significant differences between not only Applicant's invention and the McHardy/Nagahara/Kaler references but also the significant differences between the references themselves. The rejections under 35 U.S.C. §103(a) have provided no more motivation than to simply point out the individual words of the Applicant's claims among the references, but without the reason and result as provided in the Applicant's claims and specification, and without reason as to why and how the references could provide the Applicant's invention as claimed. Hindsight cannot be the basis for motivation, which is not sufficient to meet the burden of sustaining a 35 U.S.C. §103(a) rejection.

Thus, claim 1 of the present invention are therefore not taught or suggested by McHardy/Nagahara/Kaler. Combining these references as suggested by the Examiner fails to teach or yield the invention as claimed. The combination of the

McHardy/Nagahara/Kaler references fails to teach or suggest ALL the elements of claim 1. Further, one of skill in the art would not be motivated to make such a combination. Therefore, the present invention is not obvious in light of any combination of McHardy/Nagahara/Kaler. Withdrawal of the §103(a) rejection to claim 1 is therefore respectfully requested.

## Claim 2

Regarding claim 2, the Examiner admitted that McHardy and Nagahara do not teach increasing said electrical frequency of said electric field applied to said at least one pre-synaptic electrode and said at least one post-synaptic electrode, in response to generating said at least one pulse said at least one neuron, thereby strengthening at least one nanoconnection of said plurality of nanoconnections disposed within said dielectric liquid solution and strengthening said at least one synapse thereof.

The Examiner argued that Kaler teaches increasing said electrical frequency of said electric field applied to said at least one pre-synaptic electrode and said at least one post-synaptic electrode, in response to generating said at least one pulse said at least one neuron, thereby strengthening at least one pulse said at least one nanoconnection of said plurality of nanoconnections disposed within said dielectric liquid solution and strengthening said at least one synapse thereof. (The Examiner cited **Kaler**, abstract; and argued that 'Nanoconnections is strengthened or weakened according to an application of said electric field' of applicant is equivalent to 'conductance and their thickness, conductivity, and additionally asserted that fractal dimension can be controlled by varying the frequency and voltage of the applied field' of Kaler. The Examiner therefore asserted that Kaler demonstrates by varying electrical frequency the connection will be strengthened.)

The Examiner argued that it would have been obvious to a person having ordinary skill in the art at the time of applicant's invention to modify the combined

teachings McHardy and Nagahara by employing the characteristics of adjusting the conductivity as taught by Kaler to have increasing said electrical frequency of said electric field applied to said at least one pre-synaptic electrode and said at least one post-synaptic electrode, in response to generating said at least one pulse said at least one neuron, thereby strengthening at least one nanoconnection of said plurality of nanoconnections disposed within said dielectric liquid, solution and strengthening said at least one synapse thereof.

The Examiner asserted: for the purpose employing electrical fields to generate connections and conductivity between electrodes and using these selectable and adjustable properties to construct a neural network.

The Applicant respectfully disagrees with this assessment and submits that the arguments provided above against the rejection to claim 1 apply equally against the rejection to claim 2. Additionally, the Applicant submits that claim 2 as amended now includes claim limitations that render the rejection to claim 2 moot. Therefore, the Applicant respectfully requests withdrawal of the rejection to claim 2.

### Claim 3

Regarding claim 3, the Examiner argued that McHardy teaches forming a connection network within said connection gap from said plurality of nanoconnections by applying said electric field across said connection gap to said at least one pre-synaptic electrode and said at least one post-synaptic electrode associated with said plurality of nanoconnections. (citing **McHardy**, C6:67 through C7:5; 'Connection network' of applicant is equivalent to 'neural networks having many synaptic junctions' of McHardy.)

The Applicant respectfully disagrees with this assessment and submits that the arguments provided above against the rejection to claim 1 apply equally against the rejection to claim 2. Based on the arguments presented earlier with respect to claim 1 by the Applicant, it is clear that the connection network of Applicant's

invention is not equivalent to "neural networks having many synaptic junctions" of McHardy because McHardy is based on a device/technique that is completely different from that of Applicant's electromechanical based device.

#### Claim 9

Regarding claim 9, the Examiner argued that McHardy teaches configuring an adaptive artificial physical neural network (**McHardy**, abstract, C4:55-68; 'Adaptive' of applicant means 'which can be formed from a plurality of interconnected nanoconnections or nanoconnectors' is equivalent to 'growth of CAF' and 'redissolves the CAF' of McHardy.) to comprise a connection network (**McHardy**, abstract, 'Connection network' of applicant is equivalent to 'neural network' of McHardy.)

The Examiner admitted that McHardy does not teach comprising a plurality of nanoconnections formed from a dielectric liquid solution comprising a mixture of a dielectric solvent and a plurality of nanoconductors, said plurality of nanoconductors located and free to move about within said a dielectric liquid solution, wherein said plurality of nanoconductors experiences an alignment with respect to an applied electric field to form said a connection network thereof, such that said adaptive physical neural network comprises a plurality of neurons interconnected by said a plurality of nanoconnections.

The Examiner argued that Nagahara teaches comprising a plurality of nanoconnections (the Examiner cited **Nagahara**, abstract; and argued that the 'Nanoconnections of applicant is accomplished by 'nanotubes' of Nagahara.) formed from a dielectric liquid solution (the Examiner cited **Nagahara**, p3827, C2:9-22; and argued that the 'Dielectric solution' of applicant is equivalent to 'dielectric constant of the solution medium' of Nagahara.) comprising a mixture of a dielectric solvent and a plurality of nanoconductors, said plurality of nanoconductors located and free to move about within said a dielectric liquid solution, wherein said plurality

of nanoconductors experiences an alignment with respect to an applied electric field to form said a connection network thereof, such that said adaptive physical neural network comprises a plurality of neurons interconnected by said a plurality of nanoconnections. (the Examiner cited **Nagahara**, abstract, p3827, C2:9-22; and argued that 'One pre-synaptic electrode' and 'one post-synaptic electrode' of applicant is equivalent to 'electrodes' of Nagahara. The Examiner asserted that the 'Dielectric solution' of applicant is equivalent to 'dielectric constant of the solution medium' of Nagahara. The Examiner also asserted that the 'Applied electrical field' of applicant is equivalent to 'ac bias is applied' of Nagahara.)

The Examiner argued that it would have been obvious to a person having ordinary skill in the art at the time of applicant's invention to modify the teachings of McHardy by using nanoparticles for connections between electrodes as taught by Nagahara to have a plurality of nanoconnections formed from a dielectric liquid solution comprising a mixture of a dielectric solvent and a plurality of nanoconductors, said plurality of nanoconductors located and free to move about within said a dielectric liquid solution, wherein said plurality of nanoconductors experiences an alignment with respect to an applied electric field to form said a connection network thereof, such that said adaptive physical neural network comprises a plurality of neurons interconnected by said a plurality of nanoconnections.

The Examiner argued: for the purpose of generating connections between electrodes only when needed or required.

The Examiner admitted that McHardy and Nagahara do not teach locating said dielectric liquid solution within a connection gap formed between at least one pre-synaptic electrode and at least one post-synaptic electrode of said adaptive artificial physical neural network, wherein one post-synaptic electrode of said adaptive artificial physical neural network, wherein each nanoconnection among said plurality of nanoconnections is strengthened or weakened according to an

application of said electric field, such that the greater an electrical frequency or an amplitude of said electric field, the more nanoconductors among said plurality of nanoconductors align to form said plurality of nanoconnections and the stronger said artificial physical neural network thereof becomes, and wherein nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said adaptive artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said adaptive artificial physical neural network are strengthened; providing an increased frequency of said applied electric field to strengthen said plurality of nanoconnections within said adaptive physical neural network regardless of a network topology thereof.

The Examiner asserted that Kaler teaches locating said dielectric liquid solution within a connection gap formed between at least one pre-synaptic electrode and at least one post-synaptic electrode of said adaptive artificial physical neural network, wherein each nanoconnection among said plurality of nanoconnections is strengthened or weakened according to an application of said electric field, such that the greater an electrical frequency or an amplitude of said electric field, the more nanoconductors among said plurality of nanoconductors align to form said plurality of nanoconnections and the stronger said artificial physical neural network thereof becomes, and wherein nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said adaptive artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said adaptive artificial physical neural network are strengthened; providing an increased frequency of said applied electric field to strengthen said plurality of nanoconnections within said adaptive physical neural network regardless of a network topology thereof. (the Examiner cited **Kaler**, abstract; and argued that the 'Nanoconnections is strengthened or weakened

according to an application of said electric field' of applicant is equivalent to 'conductance and their thickness, conductivity, and fractal dimension can be controlled by varying the frequency and voltage of the applied field' of Kaler.)

The Examiner argued that it would have been obvious to a person having ordinary skill in the art at the time of applicant's invention to modify the combined teachings of McHardy and Nagahara by being able to adjust the thickness of the connections between the electrodes as taught by Kaler to have locating said dielectric liquid solution within a connection gap formed between at least one pre-synaptic electrode and at least one post-synaptic electrode of said adaptive artificial physical neural network, wherein each nanoconnection among said plurality of nanoconnections is strengthened or weakened according to an application of said electric field, such that the greater an electrical frequency or an amplitude of said electric field, the more nanoconductors among said plurality of nanoconductors align to form said plurality of nanoconnections and the stronger said artificial physical neural network thereof becomes, and wherein nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said adaptive artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said adaptive artificial physical neural network are strengthened; providing an increased frequency of said applied electric field to strengthen said plurality of nanoconnections within said adaptive physical neural network are strengthened; providing an increased frequency of said applied electric field to strengthen said plurality of nanoconnections within said adaptive physical neural network regardless of a network topology thereof.

The Examiner argued: for the purpose of selectivity forming (pruning) a neural network.

The Applicant respectfully disagrees with this assessment and notes that the arguments presented above against the rejection to claims 1-3 apply equally

against the rejection to claim 9. In the interest, however, of brevity, the Applicant will not repeat all of these arguments, except to note that the Examiner is incorrect in asserting that "Adaptive" of Applicant means "which can be formed from a plurality of interconnected nanoconnections or nanoconnectors is equivalent to "growth of CAF" and "redissolves" the CAF of McHardy. The Examiner is thus asserting that McHardy constitutes an "adaptive" neural network. This is clearly not the case. be referred to as an *adaptive integration network* or simply, an *adaptive network*. Adaptive neural networks to date have been limited to software designs and/or conventional hardware implementations. To date, adaptive neural networks have not been designed or implemented based on nanotechnology components, systems, and/or networks as taught by Applicant's invention. In an adaptive neural network, a connection is the conduit along which a neuron receives a signal from another neuron. Connections can be formed between neurons in any direction to transmit a signal from an output of a pre-synaptic neuron to an input of a post-synaptic neuron. Typically, a neuron plays both roles, first as a post-synaptic neuron for receiving input signals from its pre-synaptic neurons, and second as a pre-synaptic neuron for generating output signals to its post-synaptic neurons. This is not the case with McHardy but IS the case with Applicant's invention (see, for example, paragraph 0183 of Applicant's specification). An adaptive integration network can be configured to include feedback loops. A loop is a closed circuit of linked excitatory connections arranged in the same circular direction. This is not the case with McHardy.

Based on the foregoing, the Applicant submits that the rejection to claim 9 fails under all there prongs of the aforementioned prima facie obviousness test. First, there is no suggestion or motivation either in the McHardy, Nagahara and Kaler references themselves or in the knowledge generally available to one of ordinary skill in the art, to combine the teachings of McHardy, Nagahara and Kaler to provide for each and every claim limitation of Applicant's claim 9. There is also

clearly not a reasonable expectation of success for such a combination given the significant differences between the devices. Third, the prior art references when combined do not provide for the teaching or suggestion of ALL the claim limitations of Applicant's claim 9.

With regard to the first prong of the prima facie obviousness test, the Applicant reminds the Examiner that the language of the references may not be taken out of context without a motivation for such a combination, in effect producing the words of the claims (and sometimes, not even the words or concepts of the claims), without their meaning or context. The resultant combination of references would not yield the invention as claimed. Claim 9 is rejected under 35 U.S.C. §103(a) and no showing has been made to provide the motivation as to why one of skill in the art would be motivated to make such a combination, and further fails to provide the teachings necessary to fill the gaps in order to yield the invention as claimed, particularly given the significant differences between not only Applicant's invention and the McHardy/Nagahara/Kaler references but also the significant differences between the references themselves. The rejections under 35 U.S.C. §103(a) have provided no more motivation than to simply point out the individual words of the Applicant's claims among the references, but without the reason and result as provided in the Applicant's claims and specification, and without reason as to why and how the references could provide the Applicant's invention as claimed. Hindsight cannot be the basis for motivation, which is not sufficient to meet the burden of sustaining a 35 U.S.C. §103(a) rejection.

Thus, claim 9 of the present invention are therefore not taught or suggested by McHardy/Nagahara/Kaler. Combining these references as suggested by the Examiner fails to teach or yield the invention as claimed. The combination of the McHardy/Nagahara/Kaler references fails to teach or suggest ALL the elements of claim 9. Further, one of skill in the art would not be motivated to make such a combination. Therefore, the present invention is not obvious in light of any

combination of McHardy/Nagahara/Kaler. Withdrawal of the §103(a) rejection to claim 9 is therefore respectfully requested.

#### **Claim 10**

Regarding claim 10, the Examiner argued that McHardy teaches providing at least one output from at least one neuron of said plurality of neurons to an input of another neuron of said adaptive physical neural network. (the Examiner cited **McHardy**, abstract, C4:55-68; and argued that "Adaptive" of applicant means 'which can be formed from a plurality of interconnected nanoconnections or nanoconnectors' is equivalent to 'growth of CAF' and 'redissolves the CAF' of McHardy. The Examiner also argued that the 'Output of Applicant is equivalent to 'output' of McHardy.) The Applicant respectfully disagrees with this assessment and notes that the arguments presented above against the rejection to claim 10 apply equally against the rejection to claim 10. Thus, the Applicant submits that the rejection to claim 10 has been traversed. The Applicant respectfully requests withdrawal of the rejection to claim 10.

#### **Claim 23**

Regarding claim 23, the Examiner admitted that McHardy does not teach a dielectric liquid solution comprising a mixture of a dielectric solvent and a plurality of nanoconductors; at least one neuron and at least one synapse thereof, wherein said at least one synapse is configured from a plurality of nanoconnections formed from a plurality of nanoconductors disposed and free to move about within said dielectric liquid solution in association with at least one pre-synaptic electrode and at least one post-synaptic electrode thereof and an electric field applied thereof, a connection gap formed between said at least one pre-synaptic electrode and said at least one post-synaptic electrode, wherein said liquid dielectric solution is located within said connection gap.

The Examiner also asserted that Nagahara teaches a dielectric liquid solution comprising a mixture of a dielectric solvent and a plurality of nanoconductors (the Examiner cited Nagahara, abstract, p3827, C2:9-22; and argued that the 'Nanoconductors' of applicant is equivalent to 'nanotubes' of Nagahara. The Examiner also argued that the 'Dielectric solution' of applicant is equivalent to 'dielectric constant of the solution medium' of Nagahara.); at least one neuron and at least one synapse thereof, wherein said at least one synapse is configured from a plurality of nanoconnections formed from a plurality of nanoconductors disposed and free to move about within said dielectric liquid solution in association with at least one pre-synaptic electrode and at least one post-synaptic electrode thereof and an electric field applied thereof (the Examiner cited **Nagahara**, abstract, p3827, C2:9-22 and argued that 'One pre-synaptic electrode' and One post-synaptic electrode' of applicant is equivalent to 'electrodes' of Nagahara. The Examiner also asserted that the 'Dielectric solution' of applicant is equivalent to 'dielectric constant of the solution medium' of Nagahara. The Examiner additionally asserted that the 'One pre-synaptic electrode' and 'one post-synaptic electrode' of applicant is equivalent to 'electrodes' of Nagahara 'Electric field applied' of applicant is equivalent to 'ac bias is applied' of Nagahara. The Examiner also argued that the 'Neuron' of applicant is equivalent to 'nanoscale wiring' of Nagahara.); a connection gap formed between said between said at least one pre-synaptic electrode and said at least one post-synaptic electrode, wherein said liquid dielectric solution is located within said connection gap. (the Examiner cited **Nagahara**, abstract, p3827, C2:9-22; and argued that 'One pre-synaptic electrode' and 'one post-synaptic electrode' of applicant is equivalent to 'electrodes' of Nagahara. The Examiner additionally asserted that the 'Dielectric solution' of applicant is equivalent to 'dielectric constant of the solution medium' of Nagahara.)

The Examiner therefore argued that it would have been obvious to a person having ordinary skill in the art at the time of applicant's invention to modify the

teachings of McHardy by introducing components needed for the physical neural network and how they work as taught by Nagahara to have a dielectric liquid solution comprising a mixture of a dielectric solvent and a plurality of nanoconductors; at least one neuron and at least one synapse thereof, wherein said at least one synapse is configured from a plurality of nanoconnections formed from a plurality of nanoconductors disposed and free to move about within said dielectric liquid solution in association with at least one pre-synaptic electrode and at least one post-synaptic electrode thereof and an electric field applied thereof; a connection gap formed between said at least one pre-synaptic electrode and said at least one post-synaptic electrode, wherein said liquid dielectric solution is located within said connection gap.

The Examiner argued: for the purpose of establishing a base from which to construct a neural network.

The Examiner admitted that McHardy and Nagahara do not teach wherein each nanoconnection among said plurality of nanoconnections is strengthened or weakened according to an application of said electric field, such that the greater an electrical frequency or an amplitude of said electric field, the more nanoconductors among said plurality of nanoconductors align to form said plurality of nanoconnections and the stronger.

The Examiner argued that Kaler teaches wherein each nanoconnection among said plurality of nanoconnections is strengthened or weakened according to an application of said electric field, such that the greater an electrical frequency or an amplitude of said electric field, the more nanoconductors among said plurality of nanoconductors align to form said plurality of nanoconnections and the stronger (the Examiner cited **Kaler**, abstract; and argued that 'Nanoconnections is strengthened or weakened according to an application of said electric field' of applicant is equivalent to 'conductance and their thickness, conductivity, and fractal

dimension can be controlled by varying the frequency and voltage of the applied field' of Kaler.)

The Examiner therefore asserted that it would have been obvious to a person having ordinary skill in the art at the time of applicant's invention to modify the combined teachings of McHardy and Nagahara by being able to alter the thickness of the connections as taught by Kaler to have each nanoconnection among said plurality of nanoconnections is strengthened or weakened according to an application of said electric field, such that the greater an electrical frequency or an amplitude of said electric field, the more nanoconductors among said plurality of nanoconductors align to form said plurality of nanoconnections and the stronger.

The Examiner argued: for the purpose of being able to alter the connections of the neural network so it can be adaptive.

The Examiner additionally argued that McHardy teaches adaptive artificial physical neural network (the Examiner cited **McHardy**, abstract, C4:55-68; and asserted that 'Adaptive' of applicant means 'which can be formed from a plurality of interconnected nanoconnections or nanoconnectors' is equivalent to 'growth of CAF' and 'redissolves the CAF' of McHardy.)

The Examiner also stated that McHardy and Nagahara "do not teach thereof becomes", and wherein nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said adaptive artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said adaptive artificial physical neural network are strengthened and pulse generation means for generating at least one pulse from said at least one neuron to said at least one post-synaptic electrode of said at least one neuron and said at least one pre-synaptic electrode of said at least one neuron of said physical neural network, thereby strengthening at least one nanoconnection among said

plurality of nanoconnections disposed within said dielectric liquid solution and strengthening said at least one synapse thereof.

The Examiner also stated "Kaler teaches thereof becomes" and wherein nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said adaptive artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said adaptive artificial physical neural network are strengthened (the Examiner cited **Kaler**, abstract; and argued that 'Utilized more' of applicant would indicate an increase of voltage or frequency thus strengthening the connection. The Examiner also asserted that 'Not utilized' of applicant would indicate a decrease of voltage or frequency thus dissolving back the connection) and pulse generation means for generating at least one pulse from said at least one neuron to said at least one post-synaptic electrode of said at least one neuron and said at least one pre-synaptic electrode of said at least one neuron of said physical neural network, thereby strengthening at least one nanoconnection among said plurality of nanoconnections disposed within said dielectric liquid solution and strengthening said at least one synapse thereof. (the Examiner cited **Kaler**, abstract; and argued that 'Nanoconnections is strengthened or weakened according to an application of said electric field' of applicant is equivalent to 'conductance and their thickness, conductivity, and fractal dimension can be controlled by varying the frequency and voltage of the applied field' of Kaler. The Examiner asserted that therefore if a neuron is used the electrical field would increase thus improving the conductance and thickness.)

The Examiner argued that it would have been obvious to a person having ordinary skill in the art at the time of applicant's invention to modify the combined teachings of McHardy and Nagahara by having the ability to alter the conductivity of the connections as taught by Kaler to have nanoconnections among said plurality of nanoconnections that are not strengthened and thus not utilized by said adaptive

artificial physical neural network are dissolved back into said dielectric liquid solution and nanoconnections among said plurality of nanoconnections that are utilized more frequently by said adaptive artificial physical neural work are strengthened and pulse generation means for generating at least one pulse from said at least one neuron to said at least one post-synaptic electrode of said at least one neuron and said at least one pre-synaptic electrode of said at least one neuron of said physical neural network, thereby strengthening at least one nanoconnection among said plurality of nanoconnections disposed within said dielectric liquid solution and strengthening said at least one synapse thereof.

The Examiner asserted: for the purpose of having an trainable and adaptive neural network.

The Applicant respectfully disagrees with this assessment and submits that the arguments presented above against the rejection to claim 1 apply equally to the rejection to claim 23. Thus, based on these same arguments, the rejection to claim 23 fails under all there prongs of the aforementioned prima facie obviousness test. First, there is no suggestion or motivation either in the McHardy, Nagahara and Kaler references themselves or in the knowledge generally available to one of ordinary skill in the art, to combine the teachings of McHardy, Nagahara and Kaler to provide for each and every claim limitation of Applicant's claim 23. There is also clearly not a reasonable expectation of success for such a combination given the significant differences between the devices. Third, the prior art references when combined do not provide for the teaching or suggestion of ALL the claim limitations of Applicant's claim 23.

With regard to the first prong of the prima facie obviousness test, the Applicant reminds the Examiner that the language of the references may not taken out of context without a motivation for such a combination, in effect producing the words of the claims (and sometimes, not even the words or concepts of the claims), without their meaning or context. The resultant combination of references would

not yield the invention as claimed. Claim 23 is rejected under 35 U.S.C. §103(a) and no showing has been made to provide the motivation as to why one of skill in the art would be motivated to make such a combination, and further fails to provide the teachings necessary to fill the gaps in order to yield the invention as claimed, particularly given the significant differences between not only Applicant's invention and the McHardy/Nagahara/Kaler references but also the significant differences between the references themselves. The rejections under 35 U.S.C. §103(a) have provided no more motivation than to simply point out the individual words of the Applicant's claims among the references, but without the reason and result as provided in the Applicant's claims and specification, and without reason as to why and how the references could provide the Applicant's invention as claimed. Hindsight cannot be the basis for motivation, which is not sufficient to meet the burden of sustaining a 35 U.S.C. §103(a) rejection.

Thus, claim 23 of the present invention are therefore not taught or suggested by McHardy/Nagahara/Kaler. Combining these references as suggested by the Examiner fails to teach or yield the invention as claimed. The combination of the McHardy/Nagahara/Kaler references fails to teach or suggest ALL the elements of claim 23. Further, one of skill in the art would not be motivated to make such a combination. Therefore, the present invention is not obvious in light of any combination of McHardy/Nagahara/Kaler. Withdrawal of the §103(a) rejection to claim 23 is therefore respectfully requested.

#### Claim 24

The Examiner argued that McHardy teaches a connection network formed from said plurality of nanoconnections by applying said electric field to said at least one pre-synaptic electrode and said at least one post-synaptic electrode associated with said plurality of nanoconnections. (the Examiner cited **McHardy**, C6:67 through C7:5, C4:21-30; and argued that 'Connection network' of applicant is

equivalent to 'neural networks having many synaptic junctions' of McHardy. The Examiner also asserted that in this art the nanoconnections are the connections between the copper ions).

The Applicant respectfully disagrees with this assessment and notes that the arguments presented above against the rejection to claim 1 and claim 23 apply equally to the rejection to claim 24. As such, the combination of the McHardy/Nagahara/Kaler references fails to teach or suggest ALL the elements of claim 24. Further, one of skill in the art would not be motivated to make such a combination. Therefore, the present invention is not obvious in light of any combination of McHardy/Nagahara/Kaler. Withdrawal of the §103(a) rejection to claim 24 is therefore respectfully requested.

**McHardy, Nagahara, Kaler, Nugent**

Claims 6, 7, 11-21 were rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of McHardy, Nagahara and Kaler as set forth above in view of Nugent (U.S. Patent Publication 20030177450, referred to as **Nugent**)

The Applicant notes that the Examiner's arguments with respect to claims 6, 7, and 11-21 are rendered moot in light of the fact that the Nugent references is disqualified as prior art for purposes of 35 U.S.C. 103(a). This evidence by the Declaration under 37 CFR 1.130 by the Applicant, which is submitted herewith, along with a proper terminal disclaimer in accordance with 37 CFR 1.321(c), and the terminal disclaimer fee. The Applicant notes with respect to 36 CFR 1.130 when any claim of an application or a patent under reexamination is rejected under 35 U.S.C. 103 on a U.S. patent or U.S. patent application publication which is not prior art under 35 U.S.C. 102(b), and the inventions defined by the claims in the application or patent under reexamination and by the claims in the patent or published application are not identical but are not patentably distinct, and the

inventions are owned by the same party, the applicant or owner of the patent under reexamination may disqualify the patent or patent application publication as prior art. The patent or patent application publication can be disqualified as prior art by submission of a terminal disclaimer in accordance with § 1.321(c); and an oath or declaration stating that the application or patent under reexamination and patent or published application are currently owned by the same party, and that the inventor named in the application or patent under reexamination is the prior inventor under 35 U.S.C. 104.

Thus, because Nugent is not a proper references for purposes of 35 U.S.C. 103, the Applicant submits that the rejections to claims 6, 7, 11-21 under 35 U.S.C. 103(a) as being unpatentable over the combination of McHardy, Nagahara and Kaler as set forth above in view of Nugent should be withdrawn. Applicant respectfully requests withdrawal of the rejection to claims 6, 7, 11-21 under 35.

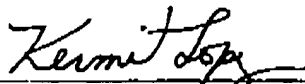
#### **IV. Conclusion**

In view of the foregoing discussion, the Applicant has responded to each and every rejection of the Official Action. The Applicant has clarified the structural distinctions of the present invention via the amendments and remarks presented herein. The Applicant submits that the amendments provided now place the application in condition for allowance. Applicant also respectfully requests withdrawal of the rejections under 35 U.S.C. §102 and §103 based on the preceding remarks. Reconsideration and allowance of Applicant's application is therefore respectfully solicited.

Should there be any outstanding matters that need to be resolved, the Examiner is respectfully requested to contact the undersigned representative to conduct an interview in an effort to expedite prosecution in connection with the present application.

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Respectfully submitted,



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